given full sway. This provides the maximum flexibility with regard to the Commission's goal of competitive delivery. To do otherwise, as noted above, benefits technologies such as APC's FAST system which lack the flexibility of ISCDMA and thus need specific rules for relocation of fixed microwave transmission.

E. Licenses Should Be Granted Based On The 194 Telephone LATAS And No National Licenses Should Be Granted To A Single Company.

CTP feels an attractive use of PCS will be to supplement or compete with present land line telephone service. The capacity of ISCDMA is such that it can handle combined mobile and wireless local loop applications in frequency sharing with fixed microwave. A single ISCDMA cell site can support upwards of 40,000 wireless local loop and mobile PCS subscribers on ten 1.25 MHz paired channels.

Because CTP thus considers PCS as in part a wireless local loop service, and because the nation's local telephone system has been set up on a LATA basis, CTP feels the strongest PCS network approach would also be based on a LATA configuration. A LATA configuration would provide the PCS license winner with large enough geographies to interest manufacturers and also facilitate tie in to present networks for network access and signalling system 7 capabilities.

Regarding national licenses, many commentators have written and spoken of the potential for the single national licensee to gain competitive advantage over regional licensees. It seems to CTP the one reason for granting national licenses is to ensure national roaming and interoperability. As noted above, PCS should not be allowed to become balkanized as was cellular. CTP feels the solution to providing national, seamless PCS service is not, however, national licenses. Rather the solution is to encourage a coalition of operators to join nationally, as CTP has done with other PCS developers to provide the needed national seamless system. If interoperability and roaming is provided by PCS developers, no national licenses are needed.

F. If Competitive Bidding Is Used, Size Of License Region Should Not Be Determined In The Bidding Process, And Also Steps Should Be Taken To Protect The Bidding Opportunity Of The Smaller, Entrepreneurial Company.

If competitive bidding is used, size of license regions should not be determined through the bidding process as suggested at page 26 of the NPRM. To bid competitively CTP feels bidders need fixed regions in advance of bidding, or the comparability of bids may be difficult to assess (see page 26 of NPRM).

As noted above, the entrepreneurial PCS developer company should be allowed a special status in the bidding. This could be accomplished through allowing the PCS developer to match bids for regions, allowing the PCS developer to bid for greater areas of the country and/or allowing the PCS developer to pay bid amounts out of cash flow. The first option would involve a two stage auction process (initial bidding followed by PCS developer opportunity to meet bids). The second option would restrict non-PCS developers to, for example, no more than three licenses while imposing no such restriction on PCS developers. The final option would allow PCS developers to pay license bids out of eventual cash flow of PCS operations while not giving a similar dispensation to others.

In any event, if competitive bidding is used, the top two bids for each license should be thrown out. This will discourage overbidding by large, well financed companies who seek to "buy" the market. While all bidding companies will presumably be doing similar financial and market analysis to determine bid price, the larger company can get capital for infrastructure construction at lower rate, and competitive bidding thus inherently favors the larger company.[10]

G. Cellular Operators Should Not Be Allowed To Acquire PCS Licenses In Their Cellular Operating Areas As Possible Anti-Competitive Behavior Is Not Balanced By Economies of Scope. Also, Those Affiliated With Cellular Operators Should Be Barred From PCS Licenses In Their Cellular Operating Areas.

At page 27 of the NPRM the Commission recognizes that while cellular operators might engage in possible anti-competitive behavior if given PCS licenses in their cellular operating areas, the Commission speculates that such grants may be justified by "economies of scope." CTP's analysis indicates there are no economies of scope in PCS, at least in ISCDMA PCS. The capital cost per subscriber to serve 20,000 subscribers is very little different from the capital cost per subscriber to serve 1,000,000 subscribers.

The reason there are no economies of scope is the capability of ISCDMA to have a single cell site base station co-located at a central office or cable TV head end and serve out of this base station, using remote antennas ("RADS"), an area of as much as 1,000 square miles. The infrastructure capital cost of such coverage would be on the order of $3.5 million, and 40,000 subscribers could be served across the 1,000 square miles by the single base station. For additional capacity, additional base stations would eventually have to be added. However,

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[10]It is to be noted that New Zealand successfully used a bidding process for its cellular licenses wherein the top bid was thrown out.

coverage cost would be kept down by continuing to use RADS, and unlike cellular radio, significant economies of scope never develop as PCS subscriber numbers are increased.

Regarding those affiliated with cellular operators, CTP feels that whatever anti-competitive behavior cellular operators might pursue (for example, packaging cellular and PCS or unfairly pricing their cellular switching and network access capabilities) also applies to companies affiliated with cellular operators. This would specifically include parents of cellular operators and majority stockholders. In response to the Commission's question, CTP also submits no de minimis overlap exception should apply as this may allow one type of anti-competitive behavior, unfairly priced switch access.

H. No Economies Of Scope Exist For LECs In PCS, And Economy Of Scope Is Not A Valid Basis For Allowing LECs To Provide PCS In Their Present Operating Areas.

As noted above, no economies of scope exist for PCS, at least for ISCDMA. Perhaps the confusion in this regard results from applying cellular radio based financial analysis to PCS. The two technologies are substantially different. Because ISCDMA (and, indeed, all CDMA approaches) can use RADs rather than base stations to gain coverage, the process of gaining necessary coverage for early subscribers is relatively inexpensive. The later addition of capacity as needed is at a relatively constant capital cost per subscriber. This applies equally to LEC and non-LEC operator so long as the non-LEC operator has equal access to the LEC telephone network.

It may be that there are operating cost savings for the LEC in providing PCS. However, these largely result from low cost access the LEC can give itself to switching and network transport services. CTP would argue these services should be provided at equal cost to non-LEC PCS operators. Thus it would appear that economy of scope is not a valid argument for allowing LECs to provide PCS in their present operating areas.

One other reason given for allowing LECs to provide PCS in their present operating areas is simply that they are corporations like others, and to deny them operating licenses would be to discriminate against them. However, LECs are certainly affiliated with cellular operators and have benefitted, at least indirectly, from that association. For that reason, and because of their local telephone operations, they are quite different from the other corporations to which LECs compare themselves.

For CTP the question of whether LECs should be allowed to be PCS providers in their operating areas is not really an issue of economy of scope or discrimination. Rather it is an issue of universality. The entrepreneurial PCS operator has an interest in offering PCS to every business and residence in the community. The marketing effort from the entrepreneurial PCS operator will be equally strong even if a particular business has just received brand new twisted pair based telephone service or a particular new residential development is currently served by extensive, undepreciated outside plant. To the LEC, on the other hand, these may be important issues. CTP believes LECs would generally use PCS for second lines, for new residential and business developments and for microcells in areas poorly served by cellular (e.g., inside railway stations). If this is true, the LECs will tend to waste of capacity and capability of the precious PCS spectrum. Universality means every residence, business and mobile user should be actively marketed for PCS. If the Commission believes the LECs will not only commit to this objective but also carry out their commitment, using PCS to aggressively bypass their embedded base and compete with their cellular operations, then LEC participation in PCS may be justified.[11] If the LECs cannot satisfy the FCC in this regard, they should not be allowed to participate in PCS on a retail basis in their present operating areas. In short, CTP recommends LECs should only be allowed PCS licenses if they commit to active marketing, and that they forfeit their licenses if later they do not meet their commitments.

A similar commitment should be required regarding network transport, switching and control capability equality of access for the PCS operator. The LEC should affirmatively commit to this prior to being granted a license and should forfeit the license if equal access commitments are not met.

I. No Restriction Should Be Placed On Number Of Licenses Or Amount Of Frequency That Can Be Gained By A PCS Developer.

CTP argued above that one approach to encouraging continuing PCS development work by PCS developers such as CTP was to provide that PCS developers could acquire any number of licenses (and frequency) they desire. For non-PCS developers, CTP submits there should be a restriction. In answer to the Commission's question on page 32 of the NPRM, CTP proposes the maximum should be three licenses. Three licenses will allow for certain economy of scale but prevent undue market concentration. These three licenses may be contiguous but should each be in a separate market.

[11]CTP has no objection to LECs or cellular radio operators participating in PCS in areas other than their present operating areas. As noted, no area overlap should be allowed in this regard.

The reason that has been given for larger groupings of licenses (and granting national licenses to a single provider) is that this will ensure seamless roaming and interoperability across the U.S. CTP's solution to this is to promote interoperability and roaming capability as a PCS but issue no national license to a single entity. Instead, encourage coalitions such as the one in which CTP is a member. In the CTP coalition entrepreneurial PCS operators in various cities are working on linking themselves in the needed seamless national PCS network.

J. Lotteries Should Be Favored Over Auctions, And Whether Lottery Or Auction, Special Status Should Be Given To PCS Developers.

PCS is a mass market service. The Commission is familiar with studies which show a U.S. PCS market of $35 to $40 billion annually by 2010 with 60 million handsets in operation. Whether these numbers are reached will depend a great deal on pricing to the subscriber. Market studies conducted by CTP and furnished to the Commission (under GEN. Docket No. 90-314 and GEN. Docket No. 92-100), as well as other studies to which CTP has access, indicate it is essential that PCS airtime subscriber charges be at or near pay telephone rates. This will be more difficult to accomplish if an auction process is used. CTP expects bidding would be lively, and the winning PCS licensee will pay upwards of $50 per POP for "good" regions even with three or more PCS licenses granted for the region. Obviously, the subscriber will ultimately pay for this, and penetration of PCS will accordingly be diminished. Because of the potential mass market utility of PCS, this is a far greater concern with PCS than it would be, for example, if auctions had been used for cellular radio or 220 MHz licenses. In sum, the Commission goal of universality would appear to be better served by a lottery process than auctions.

For PCS lotteries CTP favors a two step process as discussed earlier in this document. There should be initial pre-qualification based on business, financial and technology capability. PCS developers should be automatically pre-qualified in this process.[12] PCS lottery winners should be required to build the system to 75% coverage before any license sale is allowed, much as in the recent IVDS

[12]CTP recognizes that pre-qualification places a burden on the FCC. An alternative would be to use a "post card" lottery approach and require a complete filing of technical, financial and business capability by the lottery winner within 48 hours of the lottery win. We suggest that the standards on technical, financial and business capability be set quite high including requiring specific related business and technical capabilities. This may create some of the problems faced in the past by the Commission in comparative evaluation approaches. However, it should help in preventing lottery speculation, and most important, put PCS operation in strong hands.

lotteries (which required 50% average before license sale). The PCS lottery application fee should be as proposed in paragraph 89 of the NPRM, pages 34 and 35. Contingent winners should not be chosen but one lottery winner chosen at a time as suggested at the end of paragraph 86 of the NPRM, page 34.

It is CTP's belief that through these approaches, and particularly a stringent pre-qualification process, a lottery process can be most effective and speculation avoided. We concur entirely with Commissioner Quello's Separate Statement in the NPRM in this regard.

If auctions rather than lotteries are used, CTP proposed above that PCS developers should again be given a special position in the auction process to encourage continued PCS development. CTP suggests this could be accomplished by allowing PCS developers to meet the auction price for markets of interest. As noted, this would be a two stage process. The initial auction would be conducted and then PCS developers would be allowed to meet the auction price (or the lowest auction price as there will be multiple licenses) by notifying the Commission by sealed envelope within 30 days of the original bid. If more than one PCS developer wanted a particular license, the Commission would notify the bidding PCS developers, and they would have an opportunity to bid by sealed bid against each other. Alternatively, as suggested above, PCS developers, and PCS developers alone, would have the opportunity to bid on a basis whereby bid amounts would be paid out of eventual cash flows of the PCS system.

CTP's principal concern with the auction alternative, other than the eventual cost to subscribers, is potential unfairness to smaller, entrepreneurial PCS providers. For this reason, CTP would like to see sealed bids rather than open, oral bidding. Regarding bidding progression, the best approach would have sealed bids for the entire U.S. with all bids opened at once. As noted above, to prevent overbidding, the top two bids in each market should be thrown out. Then to prevent too large license concentration, each winning bidder would be restricted to no more than three licenses. If a bidder won more than three licenses, it would be required to withdraw from licenses of its choice to reduce to three licenses. The licenses from which the bidder withdrew would go to the next bidder in line.[13]

CTP feels that with high bids thrown out, sealed bidding with a single bid opening and restriction of winners to three licenses, amounts bid will be kept from exceeding reasonable levels. However, whatever the levels, the ultimate cost to subscribers will definitely be higher than if a lottery process is used, and auctions

[13]CTP proposes that to encourage PCS developers, they not be bound by this rule.

are basically unfair to smaller, entrepreneurial companies as cost for money (to pay the auction bid) is far lower for larger companies such as LECs.

K. PCS Should Be Classed As Common Carriage And PCS Operators Be Allowed To Resell Both Local And Long Distance Service At A Profit.

CTP believes that the four goals of the Commission are best met by allowing PCS to become alternative telephone service to current land line and cellular service, in effect common carriage. The goal of competitive diversity is particularly met by this solution. Market forces will then determine who will provide what services at what price, whether PCS operator(s), land line, cellular, IEC or alternative carrier.

This raises the issue of relative FCC and state PUC role in regulating PCS. PCS as viewed by CTP has a substantial interstate component. As previously noted, CTP is part of a national coalition to bring seamless interoperability for PCS across the U.S., and CTP looks at PCS as a nationally networked service. Further, it is very difficult to separate interstate and intrastate components in CTPs national ISCDMA network. PCS, as proposed by CTP and other members of its national network coalition, is far from being a local service.

For these reasons, CTP believes the Commission should largely pre-empt state PUCs in regulation of PCS. Further, CTP agrees with the Commission's assessment that PCS operators should not be classified as dominant carriers. Again, this conclusion provides the greatest market flexibility and ability to meet the four goals of the Commission.

L. PCS Should Be Granted Full Right Of Interconnection To The PSTN And Rates Should Be Set Based On True LEC Costs.

CTP applauds the Commission's decision to require interconnection of PCS to the PSTN. We agree with the proposal made in paragraph 101, page 40, of the NPRM and the proposal on pre-emption made in paragraph 103. However, the meaning of interconnection including technical characteristics must be specified. The history of the ONA proceedings before the Commission indicates that LECs may attempt to avoid interconnection which gives full equal access to PCS operators for LEC network transport, switching and control capabilities, the three interconnection elements needed by the PCS operator.

Regarding unique interconnect situations (paragraph 102), we note that the maximum cost and capacity advantages of ISCDMA are gained by co-locating the ISCDMA base station electronics at the LEC central office and using RADs at various points in the LEC distribution network. Traffic between base station and RADs would ideally (for lowest cost) be digitally multiplexed on copper or fiber along with current LEC land line based traffic.

Interconnection for ISCDMA in ideal configuration is thus not a simple trunk to the LEC switch but an integration into network transport, central office switch and control capability. Control capability would include signalling system 7 access.

Regarding rates, CTP believes that rates currently charged by LECs for switched access by cellular carriers include unacceptable profit margin; and the FCC should, in fact, set the ground rules, if not the actual rates, for PCS interconnection. In cellular, as the RBOC owns both the LEC and cellular operator, it makes economic sense for the RBOC to place a high charge on switch access. For the RBOC the high charge amounts to trading dollars between RBOC entities while gaining large profit from the non-wireline cellular carrier. CTP believes for similar PCS access, rates should be less than one-half what has been charged cellular carriers for access, and could be one-quarter. At this level the LEC would still make a considerable profit.

CONCLUSION

CTP has chosen to comment only on those questions raised in the NPRM which most directly affect CTP's ability to develop ISCDMA. ISCDMA is a technology with all the capabilities the FCC is seeking. It offers lower cost and higher capacity in frequency sharing with fixed microwave than any other PCS technology.

CTP's concern is that the Commission's rules may not take advantage of the full benefits of ISCDMA. A number of the Commission's proposals seem accommodations to the more limited capabilities of the APC FAST approach and similar approaches. Rather, the Commission should make its PCS rules even more flexible than proposed in the NPRM, letting negotiation, technology development and the market decide even on such issues as frequency block allocation among licensees. This is where the future of PCS lies - technologies such as ISCDMA which with elegance and simplicity automatically adjust to interference. The Commission's PCS rules should not lock on non-exportable, half way steps such as APC FAST but should provide for such technologies of the future.

PCS developers, such as CTP, should further be given continuing incentive regarding PCS development by providing them with a special status in the PCS licensing process. An unrestricted lottery or auction with no recognition given of earlier work by PCS developers will only discourage further PCS development.

Respectfully submitted,

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EXHIBIT A

EXHIBIT A

CHRONOLOGY OF CTP'S PCS DEVELOPMENT WORK

Date	Development
Summer 1988	Led in preparing British Telecom CT2 U.K. license application, resulting in award of U.K. CT2 License.
Fall/Winter 1988	Served as advisor to British Telecom on CT2; introduced CT2 to many U.S. RBOCs.
January/February 1989	Served as consultant to Pacific Telesis on CT2/PCS.
January 31, 1989	Submitted letter to Dr. Thomas P. Stanley outlining CT2/PCS -- believed to be first formal briefing to the FCC on the potential of PCS.
February 1989	Addressed the Technical Committee of the Cellular Telephone Industry Association (CTIA) on CT2/PCS -- the first formal briefing of the cellular industry.
July 1989	Appeared at FCC request on the first FCC panel addressing "The Future of CT2 Personal Mobile Communications."
Fall 1989	Formed EasyPhone, Inc. with BCE (Bell Canada Enterprises) -- believed to be first PCS company in the U.S.
Fall/Winter 1989	Conducted an extensive market study on PCS in the San Francisco Bay Area that revealed a potential market of 40 million users nationwide.
Spring 1990	Worked on technical approaches to frequency-sharing of PCS with fixed microwave.
June 1990	Invented with Bell Northern Research (BNR) the interference-sensing, dynamic channel allocation approach to PCS frequency-sharing with fixed microwave -- the first detailed approach demonstrating how narrow channel PCS could specifically co-exist with fixed microwave.
June 1990	Contacted CYLINK and initiated discussions on use of narrow channel CDMA for PCS.

Date	Development
September 14, 1990	Prepared and filed Experimental License Application for EasyPhone, Inc.
October 1990	Submitted BNR technical paper on the frequency-sharing technology to the FCC (Exhibit C to CTP's Pioneer's Preference Request, File No. PP-51).
October 1990	50-page document with attached technical paper on the frequency-sharing technology submitted by Northern Telecom ("Northern") to the FCC as Response to NOI in Gen. Docket 90-314.
October 1, 1990	Response to NOI Gen. Docket 90-314 describing the frequency-sharing technology submitted by CTP.
November 1990	Extended basic CTP/BNR technology to application use with narrow channel CDMA -- the development of the ISCDMA technology.
July 1990 - February 1990	Worked with CYLINK on specifications for narrow channel CDMA radios required for ISCDMA field testing.
October 1990 to date	Information on the frequency-sharing technical approach widely disseminated by CTP, BNR, and Northern to promote the approach adoption as a standard.
October, November 1990	Most PCS experimental licensees contacted by CTP and sent materials regarding the frequency-sharing technology. Follow-up discussions held with many experimental licensees.
November 1990	Presentation made by Northern to FCC on the frequency-sharing technology (Exhibit D to CTP's request for a pioneer's preference).
November 1990 to date	Participated as speaker in numerous industry seminars and panels describing the technology.
Spring 1991 to date	Working with Digidech, Inc. on use of narrow channel transmission technology with coaxial cable for PCS use in conjunction with cable television.
Fall/Winter 1991 to date	Working with Fulcrum Communications, Inc. of the U.K. on development of an interface between PCS and passive fiber optics for wireless local loop. The technology developed in this project is to be tested in the summer of 1992.

EXHIBIT B

NARROW CHANNEL FREQUENCY SHARING WITH FIXED MICROWAVE

Purpose. The purpose of this paper is to outline a technical approach to sharing of fixed microwave transmission frequencies with narrow channel direct sequence spread spectrum ("CDMA") for PCS purposes. The CDMA system, which will be referred to as a basis for discussion, is that of QUALCOMM Incorporated.[1] QUALCOMM is a leading developer of CDMA equipment. Its technology has been demonstrated for cellular radio use, and it has filed for a PCS pioneer's preference for its technology (File No. PP-68). In its pioneer's preference filing QUALCOMM states that it believes that by using "hard" handoff (handoff to another channel in the same PCS cell or another cell on a different frequency) and "soft" handoff (handoff to another channel in another cell on the same frequency), and other features of its system, narrow channel (QUALCOMM) CDMA can co-exist on a non-interfering basis with fixed microwave in the 1850 - 1990 MHz band. CTP agrees. In the following sections we will discuss how CTP's interference sensing approach ("ISCDMA") would be applied to the QUALCOMM technology. We will also discuss the further technology testing needed to verify that QUALCOMM's CDMA system can be immediately and widely deployed as ISCDMA PCS throughout the United States.

Background. The general technical characteristics of the QUALCOMM system are as follows:

- Direct Sequence Spread Spectrum Signal (DS-SS).
- Pseudo-Noise (PN) Spreading (Chip) Rate = 1.2288.
- Frequency division duplex (FDD) on paired channels offset 30 to 80 MHz.
- Four forward link channels embedded in each 1.2288 MHz forward transmission channel.
  - Pilot Channel
    1) Unmodulated, low power DS-SS signal. One for each forward transmission channel.
    2) Identifies unique sectors, cells.
    3) Provides nearly perfect phase/time signal strength reference.

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[1]CTP's ISCDMA could also be applied to other manufacturers' narrow channel CDMA systems.

4) Shared among all users in sector/cell and used for acquisition and tracking.

- Sync Channel

  1) Low bit rate (1200 bps) low power DS-SS signal.

  2) Allows immediate synchronization of subscriber terminal to the network.

- Paging Channel(s)

  1) Data rate flexible 2400, 4800 or 9600 bps DS-SS signal(s).

  2) Allows perfect tuning of paging capacity to system needs.

  3) Up to 7 per CDMA transmission channel.

- Traffic Channel(s)

  Data rate flexible 1200, 2400, 4800, or 9600 bps to support variable rate vocoding. Structure in 20 msec frames.

- Two reverse link channels embedded in each 1.228 MHz reverse transmission channel.

  - Access Channel(s)

    1) Used for inbound messaging when not in a call.

    2) Up to 32 per paging channel on reverse transmission.

  - Traffic Channel(s)

    Same configuration as forward traffic channel(s).

- Powerful speech coding based on CELP technology.

  - Compression to 8 Kbps.[2]

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[2]This can be increased if necessary for wireless local loop or other use.

- Idle, soft and hard handoff as described in attachments hereto.

- Use of Rake antennas.

  - Multipath used for gain.

- Very fast and accurate power control.

  - Subscriber terminal measures forward channel power and adjusts reverse channel power accordingly.

  - Base station measures reverse channel power and adjusts forward channel power accordingly.

- Soft cell capacity.

  - Dynamic optimum channel loading with lightly loaded cells contributing less noise and thus allowing busy cells to carry more traffic.

  - Means busy cells produce more summed power than "normal" cells.[3]

- Operates at low power.[4]

  - Average transmit power level of subscriber terminal of less than ten milliwatts.

- CDMA MTSO manages both handoff and channel acquisition.

  - Location of subscriber terminals upon registration.

  - Handoff implementation.[5]

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[3]This will be discussed below in connection with narrow channel CDMA frequency sharing.

[4]An important advantage for CDMA co-existing with fixed microwave. A CDMA channel can exist closer in frequency and geography to a fixed microwave transmission than can a TDMA transmission. This adds capacity in a fixed microwave environment, in addition to the general capacity gain of CDMA over TDMA.

[5]Additional, more detailed information on the QUALCOMM technology and system approach is available in a series of documents published by QUALCOMM.

For the purposes of ISCDMA, call set up is critical. In calling, the subscriber terminal:

- Powers on and performs diagnostic check.
- Scans for a pilot channel.
  - Scan will be for pilot channels in forward transmission channels in frequency order dictated by MTSO.
- Determines whether the pilot channel first found through scan is acceptable.
  - Determination is made based on power level and bit error rate of pilot channel.
- If initial pilot channel unacceptable, subscriber terminal continues scan until acceptable pilot channel found.
- Acquires pilot channel.
- Receives sync channel, receives sync channel message.
- Adjusts to system timing.
- Receives the paging channel, receives overhead information.
- Sends origination message on the access channel.
- Receives channel assignment message on the paging channel.
- Initializes the traffic channel.
- Enters conversation substate.
- Releases call and returns to sync channel.

Frequency Sharing. At the outset, it must be recognized that three problems exist in adapting QUALCOMM's CDMA for ISCDMA frequency sharing. The first is a subscriber terminal problem. It results from the fact the QUALCOMM technology does not have a separate control channel. Without access to a separate control channel which is free of microwave interference throughout the cell site and can be used for initial system acquisition and then the interference sensing process, there is danger a subscriber terminal would power up and start transmission on a frequency or in an area where the subscriber terminal would cause interference to microwave users.[6] The second problem is a base station and entire system problem. The summed power of the transmission on a channel of a CDMA cell can increase as subscriber demand increases, causing interference to neighboring fixed microwave users, whereas this would not occur in "normal" demand load operation.[7] The third problem is that the QUALCOMM system is an FDD rather than Tine Division Duplexed (TDD) system. This means that non-interfering frequency sharing must be assured for two separate frequency bands (forward and reverse bands) rather than one as in TDD.

A. Subscriber Terminal Interference Sensing.

Possible solutions to the need for subscriber terminal interference sensing before initial transmission are:

- Introduce a separate control channel by making one of the paired QUALCOMM transmission channels primarily a control channel. The MTSO would direct all subscriber terminals to first access this separate control channel upon power on. In each cell, the control channel would be a channel free of microwave interference throughout the cell. Documents filed by CTP with the Commission of the Fall of 1990 spell out in detail how this separate control channel would be used for interference sensing and call set-up. One negative to this separate control channel approach is that the QUALCOMM system would have to be reconfigured as no separate control channel is currently provided. Another negative is that traffic channels are being taken out of voice transmission service;

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[6]CTP's technology gains capacity by being able to use frequencies in a cell site that are free of microwave interference at base station site but interference blocked in some part (but not all) of the cell. This means the subscriber terminal must be able to tell at its particular location that a channel is free though blocked elsewhere in the cell. But scanning to determine interference status must be done before start of transmission or there is danger of creating a short term interference condition before the subscriber terminal can be switched to a non-interfering frequency.

[7]The CTP technical approach, as set out in the CTP/BNR patent application and other documents filed by CTP with the FCC in 1990, assumes that interfering channels at the base station will initially be excluded based on a propagation analysis at the base station site, and then all remaining useable channels scanned regularly to ascertain changes in interference creating need for further channel blockage.

and while data could also be carried on the separate CDMA control channel, some valuable capacity could be lost.

- Have the pilot channels in each cell appear only in connection with those forward transmission channels which are entirely free of microwave interference throughout the entire cell (i.e., pilot channels would be eliminated from forward transmission channels which though free of interference to fixed microwave in some parts of the cell are not free of interference in other parts of the cell). This means that the subscriber terminal on powering on in a cell would find in scanning only a pilot channel for an "approved" forward transmission channel. Interference sensing, as described by CTP, could then take over, using the paging channel; and the subscriber terminal upon scanning for interference could potentially use a transmission channel free at the subscriber terminal site but not free in certain other parts of the cell.[8] The negative to this approach is that it again requires modification of the present QUALCOMM system.

- Use the pilot channels for interference sensing. This most closely corresponds to the way the QUALCOMM system currently works.[9] At the base station site, all interfering transmission channels would be blocked from use. On other channels the pilot channel would be transmitted. The subscriber unit on power on first scans for a pilot

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[8]As described in the documents filed by CTP and Northern Telecom with FCC in October 1990 in Gen. Docket 90-314, a list of free channels at the base station site would be transmitted on the control channel (paging channel in QUALCOMM's case) and scanned for interference at the subscriber terminal site. The cell would then be set up on a channel found to be free of interference at both subscriber terminal and base station.

[9]It will be noted that CTP developed the interference sensing approach for CT2 with BNR by adapting existing features of the technology. In the case of CT2, BNR was introducing control channels for two way CT2 calling in public use and other benefits. Using these control channels and the integral capability of CT2 to sense for co-channel and adjacent channel interference, the technology was easily adapted for interference sensing of fixed microwave transmissions. Similarly, while any of the three proposals here advanced for interference sensing CDMA would work, CTP likes best an approach which takes maximum advantage of existing capabilities of the technology, thereby saving complexity and cost.

channel on a forward transmission channel. If the pilot channel it first scans has low power or exhibits bit error transmission problems, the subscriber terminal continues the scan until it finds a pilot channel with strong power and low bit error rate.[10]

In a fixed microwave environment, microwave interference would cause substantial pilot channel signal degradation. The pilot channel operates at very low power and quickly becomes indecipherable to the subscriber terminal in conditions of a low degree of microwave interference. This means that if the subscriber terminal powered on, scanned a pilot channel which at base station site was free of interference, found that because of fixed microwave interference at the subscriber terminal site that the pilot channel was unusable, the subscriber terminal would reject the channel and continue the scan. Correspondingly, if a particular forward transmission channel is free at some parts of the cell (including the base station) but not others, and if the subscriber terminal is in a free zone, upon power on the subscriber terminal would find the pilot channel; and the transmission channel would become a useable channel by the subscriber terminal, despite the fact it might be an interfering channel if used in certain other parts of the cell. The result would be in accordance with CTP's ISCDMA approach with an increase in cell site capacity.[11] Pilot channel interference sensing would also be used if a subscriber terminal moved within a cell from an interference free zone to one where interference to and from fixed microwave was possible. Under these circumstances, degradation of the pilot channel would occur and hard or soft handoff initiated.[12]

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[10]The specific parameters for pilot channel strength measurement are proprietary to QUALCOMM.

[11]It will be noted that this process is described in the technology discussion produced in September 1990, submitted to the FCC in October 1990, though there applied to CT2 Plus. The subscriber terminal, as there described upon power up scans for control channels and chooses the best channel on which to register and commence transmission.

[12]In idle mode (subscriber terminal on but no traffic transmission) and in transmission mode, the subscriber terminal constantly searches for the strongest pilot channel. Idle handoff occurs when the subscriber terminal finds a stronger pilot channel, and idle handoff occurs to the forward transmission channel which has the strongest pilot channel. Similarly hard and soft handoff is made to the transmission channel with the strongest pilot channel. This gives an extra margin of protection to the fixed microwave

For interference sensing through pilot channels to give adequate protection to microwave users, pilot channels must become unusable (upon power on scanning or upon movement of subscriber terminal into interfering zone) at a threshold where the fixed microwave user is assured no detectable interference will occur to the fixed microwave transmission. This will have to be tested. It was, however, QUALCOMM's initial opinion that the power level on the pilot channel and the receiver sensitivity of the subscriber terminal regarding the pilot channel are already together set at a threshold such that pilot channels would become unusable before associated traffic channels become potential interferers to fixed microwave transmission.[13] The threshold with regard to pilot channel access must, of course, be set rigorously enough that absolute protection is given to the microwave user.[14]

B. Effect of Summed Power.

As noted above, the approach outlined in CTP's pioneer's preference request involves initial exclusion of interfering channels and regular base station scanning of remaining useable channels. In a CDMA system this approach must deal with the increase in power in a cell (and the increased summed power of all transmissions on a certain potentially interfering frequency in a cell) which occurs when demand in a CDMA cell increases relative to neighboring cells. Possible solutions are:

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user as a pilot channel only slightly degraded by fixed microwave interference would be rejected for a pilot channel not so degraded (i.e., a stronger pilot channel).

[13]Note that in cases where the subscriber terminal is very near the base station a pilot channel might be adequately received by the subscriber terminal despite microwave interference. However, the accompanying transmission channel would already have been blocked out by the base station which would have identified the same microwave interference from the base station site.

[14]Obviously the question is not whether fixed microwave interferes with the CDMA channel but whether the thresholds are set rigorously enough to protect fixed microwave users from the CDMA channel. This must be at a level where the summed power of all transmissions on a channel do not interfere with the fixed microwave transmission.

It should also be noted that use of pilot channels for interference sensing accomplishes frequency agility and the ability to move handsets throughout the U.S. (on ISCDMA systems) as outlined in the CTP/BNR patent application and other papers filed with the FCC in 1990.

- Do the initial channel exclusion at base station site based on "normal" operation, and then incorporate an algorithm which removes additional channel(s) from use as summed power on the channel(s) increases. These would be channels which were "near interferers" in that while acceptable to the fixed microwave user at normal base station power, might cause interference at higher summed power. Of course, the effect of this solution would be to remove channel capacity just as it is needed - in a high demand situation.

- Exclude initially all channels which at highest summed power might interfere at base station site with fixed microwave. This means lost capacity in normal operation, but in normal use the capacity might not be needed in any case.

- Use pilot channel interference sensing. When demand increases in a CDMA cell relative to neighboring cells, the high demand cell expands in power to serve the demand, and "borrows" capacity from neighboring, lower demand cells. Subscriber terminals near the edge of the high demand cell will find pilot channel signals degraded by distance and interference caused by the high number of users already on the particular transmission channel. If the transmission channel is additionally a "near interferer" to a fixed microwave transmission, this interference will be added to the signal degradation caused by distance and high demand user interference. The result will be that as demand increases, and summed power on a given transmission channel starts to increase, pilot channel degradation should prevent addition of subscriber terminals which will turn near interference into actual interference to the fixed microwave user. Again, this will have to be tested.

C. Use of FDD Rather than TDD.

QUALCOMM has already suggested an answer to the problem of having to coordinate paired channels (FDD) in a fixed microwave environment. The answer is to use the same channel offset as used by the fixed microwave transmission, normally 80 MHz.[15] Thus proper non-interfering coordination of the forward or reverse channels would correspondingly result in coordination of the reverse or forward channels.[16]

ISCDMA in Practice. CDMA has demonstrated capacity advantages over TDMA. These advantages grow in operation in a fixed microwave environment. A CDMA channel can operate closer in geography and frequency to a fixed microwave transmission without interfering with the transmission because of CDMA spectrum spreading and low power. This translates to additional capacity.[17] The capacity of ISCDMA depends upon both fixed microwave interference and cell size in a geography.

A. Low Interference Geographies.

Clearly the capacity of narrow channel CDMA is such in many parts of the country that the equivalent of 120 MHz that may be eventually needed for PCS can be found by simple frequency coordination approaches.[18] All potentially interfering channels in a given cell in many parts of the country

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[15]It is to be noted that an FDD system has one advantage over a TDD system in application of the CTP interference sensing approach. Assume a quite distant microwave transmitter (30 miles or more) and a nearby microwave receiver. In a TDD system the subscriber terminal threshold of interference sensing would have to be very carefully set to ensure that the distant microwave interferer was in fact heard and subscriber transmission not commenced on the same TDD channel, causing interference to the nearby microwave receiver. On the other hand, with both microwave transmissions and CDMA FDD transmissions offset at 80 MHz, the microwave receiver that would be affected by the subscriber terminal transmission would be the 30 mile plus distant microwave receiver in the example given, resulting in perceived interference to subscriber terminal equating to far less than actual interference to microwave receiver.

[16]Another possible problem for the QUALCOMM system in a fixed microwave environment is soft handoff. It appears, however, that even though different pilot channels (and transmission channels) will be unavailable in different cells because of fixed microwave interference, the QUALCOMM system would easily adjust to this, using hard handoff where soft handoff is unavailable.

[17]It should be noted that the capacity increase of CDMA over TDMA is greater in a fixed microwave frequency sharing environment than, for example, in cellular radio use in the absence of direct interference.

[18]See CTP's and Northern Telecom's filings with the FCC regarding PCS NOI (Gen. Docket No. 90-314) in October 1990 which detail frequency need.

could be blocked out and there would still be enough free frequency in the 1850 - 1990 MHz band to provide adequate PCS capacity using CDMA. This is particularly true where areas of low microwave interference correspond to areas of low PCS demand (more rural or suburban areas).

In such geographies, the advantages of ISCDMA lie not in capacity gain but in certainty gain.

- Regulatory certainty. Under ISCDMA whether scanning is done using pilot channels, or using a separate control channel, channel rejection depends upon sensed thresholds of interference. These thresholds can be set so that no detectable interference can occur to the fixed microwave user. ISCDMA subscriber terminals can then be moved throughout the country, into a variety of fixed microwave transmission conditions, and wherever they are, the subscriber terminals will not interfere. Similarly, if interference sensing is incorporated in base stations as described in CTP's pioneer's preference request, no base station could operate on a channel which interferes with fixed microwave transmission at the base station site. This means that if channel exclusions are improperly computed when the base station is sited (certain interfering channels not removed from the list of useable channels), or if the base station is moved to a new area (moved wireless PBX, residential cordless phone or perhaps Telepoint base station) the base station would automatically adjust to exclude interfering channels at base station site. By factory setting of interference sensing thresholds in base stations and subscriber terminals all possibility of fixed microwave interference from ISCDMA PCS is prevented throughout the U.S. Regulation for the FCC becomes merely a matter of assuring proper interference sensing thresholds are set for subscriber terminals and base stations. This could be done through FCC type acceptance procedures.

  Contrast this to what might be involved if the FCC is required to regulate PCS operators using so called "exclusion zones" as the basis for frequency sharing of PCS with fixed microwave. In an exclusion zone approach interference sensing is not used. Instead each cell must be carefully mapped in its entirety for possible interference to fixed microwave in any part of the cell. Channels which might produce detectable interference to fixed microwave interference in any part of the cell are excluded from use by base station and subscriber terminal. The remaining channels alone are used. Under these circumstances, protection of the microwave user becomes a matter of the accuracy of the initial interference mapping and the careful adherence of the PCS operator to the restrictions indicated by the mapping.[19] Regulation under these circumstances could require examination of interference maps and mapping techniques of PCS operators, and policing of adherence to mapped exclusion requirements. This would be an impossible regulatory task.

- Certainty of protection for fixed microwave users. Under ISCDMA, the fixed microwave user knows that each PCS base station and subscriber terminal is configured with interference sensing at thresholds giving absolute protection against detectable interference to fixed microwave. This certainty should allow present fixed microwave users to drop opposition to PCS sharing with fixed microwave. CTP believes that the alternative frequency sharing approaches of broad band CDMA or use of exclusion zones would be seen as affording less certain protection by fixed microwave users. Adoption of either of these approaches could result in continuing opposition to frequency sharing from fixed microwave users.

B. High Interference Geographies.

In certain metropolitan areas enough fixed microwave transmission exists in the 1850 - 1990 MHz band that even narrow channel CDMA, with its high

[19]Note too, one defect of the exclusion zone approach is that once mapping is done no further microwave users can be admitted to the area without remapping and recreating exclusion zones. ISCDMA, on the other hand, allows entrance of new microwave users as the system would dynamically adjust for the new interference of the new users. This is why since September 1990 CTP has been stating its approach would, with certain restrictions, allow secondary rather than co-primary status with fixed microwave.